Engagement Opportunities in NASA STEM 2023 (EONS-2023)
NASA Research Announcement (NRA)
MUREP Space Technology Artemis Research (M-STAR)
Number: NNH23ZHA001N-MSTAR

Title: Additive Manufacturing on the Moon: Exploring the Potential of Laser Wire Directed Energy Deposition for Metallic Component Fabrication

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FY: 2023

Summary: This proposal aims to build NASA's capability for manufacturing on the Moon through a collaborative investigation between Cal State Los Angeles and the Jet Propulsion Lab (JPL) on the use of laser wire directed energy deposition (LW-DED) for additive manufacturing (AM), focusing on three main research areas along with several educational and outreach activities. First, we will study the behavior and properties of LW-DED printed samples contaminated/mixed with lunar dust. Second, we will model the LW-DED process under terrestrial and reduced gravity conditions to evaluate the behavior and microstructure of the 3D printed materials, including process modeling and microstructural modeling. Last, we will create a design process specific to the constraints of space and the use of AM to build and test components of lunar vehicles such as wheels and suspension components, using LW-DED.

In the first area of investigation, we will model the LW-DED process under both terrestrial and reduced gravity conditions. We will use process modeling to optimize the LW-DED parameters for the lunar environment, such as the effects of reduced gravity on the melting process. Additionally, we will use micro-scale modeling to understand the microstructural evolution of the deposited material and its mechanical properties. In the second area of investigation, we will study the effects of lunar dust on the properties and behavior of LW-DED printed samples. Lunar dust is a significant challenge for manufacturing on the moon, as it can contaminate and affect the properties of materials. We will investigate the effects of different concentrations of lunar dust on the LW-DED process, including changes in mechanical properties and microstructure. In the last area of the investigation, we will focus on creating a design process specific to the constraints of space and the use of additive manufacturing in order to optimize lunar vehicle components for manufacture on the Moon through LW-DED. These components are critical for the success of lunar exploration and settlement and utilizing LW-DED for their production offers many advantages for the voluminous, yet light components of lunar vehicles. We will optimize the design and material properties for the lunar environment and evaluate the performance of the components under simulated lunar conditions with the project partners at JPL. The proposed research has significant implications for the future of lunar exploration and settlement. The ability to utilize LW-DED for additive manufacturing using lunar resources offers the potential for sustainable lunar exploration and settlement. Additionally, the knowledge gained from

studying the effects of lunar dust and modeling the LW-DED process under reduced gravity conditions can contribute to the development of other lunar manufacturing technologies.

In addition to the planned research, the project will support a multifaceted effort to enhance diversity and education in science and engineering fields at NASA and in manufacturing engineering more broadly. Specifically, we aim to establish a project within the LAunchPad summer program for women entering college, develop collaborative curricula with community colleges, expand our material science and engineering program, and implement an internship program for undergraduate and graduate students between Cal State LA and the JPL. Our approach integrates research opportunities within these educational activities to promote hands-on learning and skill-building. Through these efforts, we seek to provide students with the necessary tools and resources to succeed in STEM fields and contribute to the advancement of science and technology.

Through the outcomes of this research, we will advance our understanding of lunar manufacturing, contribute to the development of a sustainable lunar economy, and work towards a thriving and diverse manufacturing workforce.